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| 09/995,421 | 11/27/2001 | Won-Young Chung | 5649-909 | 1882 |

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| EXAMINER | |
|---|---|
| GEBRESILASSIE, KIBROM K | |
| **ART UNIT** | **PAPER NUMBER** |
| 2128 | |

DATE MAILED: 11/20/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 09/995,421 | CHUNG ET AL. | |
| | Examiner | Art Unit | |
| | Kibrom K. Gebresilassie | 2128 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on 29 August 2006.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) 1-28,30-32,34 and 35 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-28,30-32,34 and 35 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

## DETAILED ACTION

1. This communication is responsive to the amended application filed on August 29, 2006.

2. Claims 29, and 33 are canceled.

3. Claims 1-28, 30-32, and 34-35, are pending.

### *Response to Arguments*

4. Applicant's arguments with respect to claims 1-28, 30-32, and 34-35 have been considered but are moot in view of the new ground(s) of rejection.

### *Claim Rejections - 35 USC § 102*

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.

6. Claims 1-3, 5-12, 14-21, 23-28, 30-32, and 34-35 are rejected under 35 U.S.C. 102(a) as being anticipated by W. Y. Chung, J. J. Oh, T. K. Kim, J. K. Shin, K. Seo, Y. K. Park, and J. T. Kong, "Integrated Simulation of Equipment and Topography for Plasma Etching in the DRM Reactor," 2000 IEEE, Herein referred as **Chung**.

**As per Claim 1:**

Chung discloses a method of estimating characteristics of a plasma contained in a reaction chamber of a plasma reactor including a plurality of magnets that move with respect to the reaction chamber (analogous to "...the magnetic fields arising from the rotating magnets." Page 127, Right side column, lines 3-7), the method comprising:

obtaining configuration and process condition data for the reaction chamber (analogous to "profiles in terms of the equipment operating parameters such as the gas composition ratio and power." Abstract; Fig. 1, Step one);

computing plasma characteristics for each of a plurality of cross-sections of the reaction chamber from the configuration and process condition data (analogous to "The plasma parameters are computed at several 2-dimensional cross-sections with a distinctive magnetic field distribution…." (See: Page 128, left side column, lines 1-3)); and

generating a generalize model of the plasma from the computed plasma characteristics for the plurality of cross-sections (analogous to "…and overall etching characteristics are obtained by averaging over these several 2-D calculations." (See: page 128, left side column, line 3)).

**As per Claim 2 (Original):**

Chung discloses the plurality of moving magnets rotate about an axis of rotation, and wherein each of the plurality of cross-sections includes the axis of rotation (analogous to "…the magnetic fields arising from the rotating magnets." Page 127, Right side column, lines 3-7).

**As per Claim 3 (Original):**

Chung discloses a method according to Claim 1, wherein computing plasma characteristics for each of a plurality of cross-sections of the reaction chamber comprises performing the following actions for each of the cross-sections:

computing electron density and temperature for the cross-section using an iterative Monte Carlo computational procedure (analogous to "...the energy and angular distributions of all particles striking the wafer are obtained using Monte Carlo Simulation." Page 128, left side column, lines 10-12); and

computing ion and neutral species transmission phenomena for the cross-section from a plasma dynamics simulation (analogous to "Ion Angular Distribution, Ion Energy Distribution in Kinetic Simulation" Fig. 1 Step 4).

**As per Claim 5 (Original):**

Chung discloses determining a static magnetic field generated by the moving magnets (analogous to "...the magnetic fields arising from the rotating magnets." Page 127, Right side column, lines 3-7), and wherein computing plasma characteristics for each of a plurality of cross-sections of the reaction chamber comprises computing the plasma characteristics for each of the plurality of cross-sections from the determined static magnetic field, shape information for the reaction chamber, and plasma collision reaction data (analogous to "The plasma parameters are computed at several 2-dimensional cross-sections with a distinctive magnetic field distribution...." (See: Page 128, left side column, lines 1-3)).

**As per Claim 6 (Original):**

Chung discloses generating a generalized model of the plasma from the computed plasma characteristics for the plurality of cross-sections comprises computing at least one of an electron density distribution, a temperature distribution, a distribution of ion species, a distribution of neutral species, and a flux incidence (analogous to "Ion,

Radical Fluxes, E-field Density, Ion Angular Distribution, Ion Energy Distribution." See: Fig. 1 and Fig. 4).

**As per Claim 7 (Original):**

Chung discloses generating a generalized model of the plasma from the computed plasma characteristics for the plurality of cross-sections comprises averaging the computed plasma characteristics for each of the plurality of cross-sections (analogous to "...and overall etching characteristics are obtained by averaging over these several 2-D calculations." (See: page 128, left side column, line 3 )).

**As per Claim 8 (Original):**

Chung discloses estimating an etching rate for a wafer positioned in the chamber from the generalized model of the plasma (analogous to "...the uniformity of the etch rate and profile evolution are obtained in terms of plasma process conditions." Page 128, left side column, Second Paragraph).

**As per Claim 9 (Original):**

Chung discloses the plasma reactor comprises a dipole ring magnet (DRM) plasma reactor (analogous to "DRM Reactor" Abstract).

**As per Claim 10:**

Chung discloses an apparatus for estimating characteristics of a plasma contained in a reaction chamber of a plasma reactor including a plurality of magnets that move with respect to the reaction chamber (analogous to "...the magnetic fields arising from the rotating magnets." Page 127, Right side column, lines 3-7), the apparatus comprising:

means for obtaining configuration and process condition data for the reaction chamber (analogous to "profiles in terms of the equipment operating parameters such as the gas composition ratio and power." Abstract; Fig. 1, Step one);

mean for computing plasma characteristics for each of a plurality of cross-sections of the reaction chamber from the configuration and process condition data (analogous to "The plasma parameters are computed at several 2-dimensional cross-sections with a distinctive magnetic field distribution….." (See: Page 128, left side column, lines 1-3)); and

means for generating a generalize model of the plasma from the computed plasma characteristics for the plurality of cross-sections (analogous to "…and overall etching characteristics are obtained by averaging over these several 2-D calculations." (See: page 128, left side column, line 3 )).

**As per Claims 11 and 20 (Original):**

The limitations of claims 11 and 20 have already been discussed in the rejection of Claim 2. They are therefore rejected under the same rationale.

**As per Claims 12 and 21 (Original):**

The limitations of Claims 12 and 21 have already been discussed in the rejection of Claim 3. They are therefore rejected under the same rationale.

**As per Claims 14 and 23 (Original):**

The limitations of Claims 14 and 23 have already been discussed in the rejection of Claim 5. They are therefore rejected under the same rationale.

**As per Claims 15 and 24 (Original):**

The limitations of Claims15 and 24 have already been discussed in the rejection of Claim 6. They are therefore rejected under the same rationale.

**As per Claims 16 and 25 (Original):**

The limitations of Claims 16 and 25 have already been discussed in the rejection of Claim 7. They are therefore rejected under the same rationale.

**As per Claims 17 and 26 (Original):**

The limitations of Claims 17 and 26 have already been discussed in the rejection of Claim 8. They are therefore rejected under the same rationale.

**As per claims 18 and 27 (Original):**

The limitations of Claims 18 and 27 have already been discussed in the rejection of Claim 9. They are therefore rejected under the same rationale.

**As per Claim 19 (Original):**

Chung discloses a computer program product for estimating characteristics of a plasma contained in a reaction chamber of a plasma reactor including a plurality of magnets that move with respect to the reaction chamber (analogous to "...the magnetic fields arising from the rotating magnets." Page 127, Right side column, lines 3-7), the computer program comprising:

program code obtaining configuration and process condition data for the reaction chamber (analogous to "profiles in terms of the equipment operating parameters such as the gas composition ratio and power." Abstract; Fig. 1, Step one);

program code computing plasma characteristics for each of a plurality of cross-sections of the reaction chamber from the configuration and process condition data

(analogous to "The plasma parameters are computed at several 2-dimensional cross-sections with a distinctive magnetic field distribution...." (See: Page 128, left side column, lines 1-3)); and

program code generating a generalize model of the plasma from the computed plasma characteristics for the plurality of cross-sections (analogous to "...and overall etching characteristics are obtained by averaging over these several 2-D calculations." (See: page 128, left side column, line 3)).

**As per Claim 28 (Currently Amended):**

Chung discloses a method of simulating plasma in a plasma apparatus having a plasma reactor and a plurality of paramagnet magnets which are asymmetrically arranged and rotate around plasma reactor at predetermined speed, comprising the steps of:

(a) inputting shape and process conditions (analogous to "profiles in terms of the equipment operating parameters such as the gas composition ratio and power." Abstract; Fig. 1, Step one) and inputting plasma collision reaction data (analogous to "contact profile"; Abstract);

(b) 3-dimensionally computing static magnetic fields induced by the permanent magnets (analogous to "...the magnetic field induced by complex permanent magnets of the DRM equipment are 3-dimensionally computed using a commercial software, VectorFields." Page 127, right side column, Under a title "The Simulation Flow and Etch Model"; Fig. 1 Step two);

(c) computing electron density and temperature and interpreting the transmission phenomenon of ion and neutral species using the data of the steps (a) and (b) until they are converged (analogous to “good agreement of the calculated and measured values and distribution” Page 127, right side column, Under a title “The Simulation Flow and Etch Model” );

(d) obtaining overall plasma characteristics using the converged values (analogous to “...and overall etching characteristics are obtained.” Page 128, left side column, line 3); and

wherein the step(c) comprises plasma simulation at 2-dimensional cross-sections for cross-sectional magnetic field distribution in a characteristics magnetic field direction (analogous to “...based on VectorFields to accurately take account the magnetic fields arising from the rotating magnets.” (See: page 127, right side column, lines 4-8)).

**As per Claim 29 (Canceled):**

**As per Claim 30 (Currently Amended):**

Chung discloses 2-dimensional plasma simulation is performed for a plurality of 2-dimensional cross-sections including an axis, obtains convergence values for the respective cross-sections, and averages them to obtain plasma characteristics (analogous to “...and overall etching characteristics are obtained by averaging over these several 2-D calculations.” (See: page 128, left side column, line 3 )).

**As per Claim 31:**

Chung discloses wherein the plasma apparatus is DRM plasma apparatus (analogous to "DRM Reactor" Abstract)

**As per Claim 32 (Currently Amended):**

Chung discloses computer readable recording media configured to support simulation of plasma in a plasma apparatus having a plasma reactor and a plurality of paramagnet magnets which are asymmetrically arranged and rotate around plasma reactor at predetermined speed, the computer readable recording medium configured to include a plurality of program modules comprising:

(a) a program module for inputting shape and process conditions (analogous to "profiles in terms of the equipment operating parameters such as the gas composition ratio and power." Abstract; Fig. 1, Step one) and inputting plasma collision reaction data (analogous to "contact profile"; Abstract);

(b) a program module for 3-dimensionally computing static magnetic fields induced by the permanent magnets (analogous to "...the magnetic field induced by complex permanent magnets of the DRM equipment are 3-dimensionally computed using a commercial software, VectorFields." Page 127, right side column, Under a title "The Simulation Flow and Etch Model"; Fig. 1 Step two);

(c) a program module for computing electron density and temperature and interpreting the transmission phenomenon of ion and neutral species using the data of the steps (a) and (b) until they are converged (analogous to "good agreement the calculated and measured values and distribution" Page 127, right side column, Under a title "The Simulation Flow and Etch Model" );

(d) a program module for obtaining overall plasma characteristics using the converged values (analogous to "...and overall etching characteristics are obtained." Page 128, left side column, line 3); and

wherein the step(c) comprises plasma simulation at 2-dimensional cross-sections for cross-sectional magnetic field distribution in a characteristics magnetic field direction (analogous to "...based on VectorFields to accurately take account the magnetic fields arising from the rotating magnets." (See: page 127, right side column, lines 4-8)).

**As per Claim 33 (Canceled):**

**As per Claim 34 (currently Amended):**

Chung discloses 2-dimensional plasma simulation is performed for a plurality of 2-dimensional cross-sections including an axis, obtains convergence values for the respective cross-sections, and averages them to obtain plasma characteristics (analogous to "...and overall etching characteristics are obtained by averaging over these several 2-D calculations." (See: page 128, left side column, line 3 )).

**As per Claim 35 (Original):**

Chung discloses wherein the plasma apparatus is DRM plasma apparatus (analogous to "DRM Reactor" Abstract).

***Claim Rejections - 35 USC § 103***

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham* **v.** *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

8. Claims 4, 13, and 22 are rejected under 35 U.S.C. 103(a) as being unpatentable over W. Y. Chung, J. J. Oh, T. K. Kim, J. K. Shin, K. Seo, Y. K. Park, and J. T. Kong, "Integrated Simulation of Equipment and Topography for Plasma Etching in the DRM Reactor," 2000 IEEE, Herein referred as **Chung**, as applied to claims 1-3, 5-12, 14-21, 23-28, 30-32, and 34-35 above, and further in view of P.L.G. Ventzek, R. J. Hoekstra, and M. J. Kushner, "Two-dimensional modeling of high plasma density inductively coupled sources for materials processing," 1994 American Vacuum Society, herein referred as **Ventzek**.

**As per Claim 4 (Original):**

Although, Chung discloses the ion and neutral species transmission phenomena for the cross-section from a plasma dynamics simulation such as obtaining ion angular distribution, ion energy distribution in kinetic simulation using a Monte Carlo simulation (See: Fig. 1 Step 4).

Chung fails expressly to disclose computing solutions to a continuity equation and Poisson's equation for the ion and neutral species.

Ventzek discloses computing solutions to a continuity equation and Poisson's equation for the ion and neutral species such as solving the continuity equations and Poisson's equation for all charges and neutral species in Fluid Chemical Kinetic Simulation (See: Page 464, Right side column, lines 9-11 and Equation 12 and Equation 13).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to combine the teachings of Ventzek et al with Chung et al because both references are clearly concerned with etching process of semiconductor materials. The motivation for doing so would have been more convenient to solve the Poisson's equation for a future time using a prediction for the charge densities based on the present values of their time derivatives to overcome the limitation imposed by dielectric relaxation time (See: Page 465, left side column, lines 27-31).

**As per Claims 13 and 22 (Original):**

The limitations of Claims 13 and 22 have already been discussed in the rejection of Claim 4. They are therefore rejected under the same rationale.

## *Conclusion*

9. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

*R. A. Stewart, P. Vitello, and D. b. Graves, "Two-dimensional fluid model of high density inductively coupled plasma sources," 1994 American Vacuum Society, pgs. 478-485.*

*P.L. G. ventzek, T. J. Sommerer, R. J. Hoekstra, and M. J. Kushner, "Two-dimensional hybrid model of Inductively Coupled plasma source for etching, Appl. Phys. Lett. 63 (5), 2 August 1993, pgs. 605-607.*

*T. Ohiwa, I. Hasegawa, and M. Sekine, "A New High Density Plasma Etching System Using A Dipole-ring Magnet (DRM)", 1993 IEEE.*

10. Any inquiring concerning this communication or earlier communication from the examiner should be directed to Kibrom K. Gebresilassie whose telephone number is (571) 272-8571. The examiner can normally be reached on Monday-Friday, 8:30 am to 4:30 pm. If attempts to reach the examiner by telephone are unsuccessful, the examiner supervisor, Kamini S. Shah can be reached at (571) 272-2279. The official fax number is (571) 273-8300. Any inquiring of a general nature relating to the status of this application should be directed to the group receptionist whose telephone number is (571) 272-3700.

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